ACTIVITY OF LAMBDA-CYHALOTHRIN APPLIED AS AN ULTRALOW VOLUME GROUND TREATMENT AGAINST *ANOPHELES QUADRIMACULATUS* ADULTS[1]

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ABSTRACT. Lambda-cyhalothrin was evaluated as an ultralow volume ground adulticide treatment at rates of 0.25, 0.5 and 1.0 g/ha. Resmethrin, a standard adulticide, was applied at a rate of 1.96 g/ha. All treatments provided ≥95% control up to 50 m from the spray route. The highest rate of lambda-cyhalothrin and the resmethrin standard provided ≥95% control up to 200 m, which is twice the distance normally assessed in this type of testing. Control was reduced at 200 m for the 0.25 and 0.5 g/ha rates of lambda-cyhalothrin, which provided 73 and 88% mortality, respectively. Lambda-cyhalothrin appears to have the insecticidal activity required for operational mosquito control.

INTRODUCTION

Mosquito control programs in the rice-producing region of Arkansas rely on effective ultralow volume (ULV) ground adulticide applications to maintain mosquito densities at acceptable levels in urban areas. *Anopheles quadrimaculatus* Say is one of the primary pest mosquito species in this region for which control measures are implemented. It is the major pest of humans and animals during mid- to late summer, and peak adult density normally occurs during August (Meisch and Inman 1990).

The most effective mosquito control programs in the region are based upon rice field larviciding with the microbial agent *Bacillus thuringiensis* (H-14) (Meisch and Inman 1988). Communities that rely on this progressive approach augment larviciding programs with ULV ground and/or aerial adulticide treatments as needed.

Combination ground and aerial adulticide treatments were shown to provide control of *An. quadrimaculatus* for 48 h in an Arkansas riceland community (Weathersbee et al. 1986). This is not to be expected when only ground treatments are used since adult females of the species can disperse 1.8 ± 1.0 km in one day (Weathersbee and Meisch 1990). Thus, nightly ground applications are often required in urban areas during periods of peak adult mosquito density (Mount et al. 1972, Coombes and Meisch 1976).

Frequent use of the few available materials that perform adequately as mosquito adulticides demands a search for new alternative control strategies. This experiment was undertaken to evaluate the activity of lambda-cyhalothrin applied as a ULV ground treatment against *An. quadrimaculatus* adults.

MATERIALS AND METHODS

Lambda-cyhalothrin was evaluated as a ULV ground treatment applied at 0.25, 0.5 and 1.0 g AI/ha against caged adult *An. quadrimaculatus* in a fallow field located approximately 5 km east of Stuttgart, AR. Comparisons were made with a standard insecticide formulation containing synergized resmethrin applied at 1.96 g resmethrin/ha. Replicate tests were conducted between 1915 and 2030 h on the evenings of July 24–26, 1990. Temperature during the tests ranged from 28.3 to 30.5°C and wind velocity, measured with a ball-movement anemometer, ranged from 0 to 3.2 kph from the east-southeast.

Adult mosquitoes were captured late in the afternoon on the day of each test from a natural population of *An. quadrimaculatus* resting in a livestock barn near Stuttgart. Mosquitoes were collected with a battery-powered backpack vacuum (United States Department of Agriculture, Medical and Veterinary Entomology Laboratory, Gainesville, FL) equipped with screened half-pint paper cartons as collection containers. Polystyrene containers were used to transport mosquitoes to the laboratory where they were anesthetized with CO_2 and transferred to screened test cages (Sandoski et al. 1983). Approximately 25 mosquitoes (87% females) were placed in each cage. Cages for each treatment and control were packed in separate polystyrene containers for transport to the test site.

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Treatments were applied by truck-mounted LECO® HD cold aerosol generators along a south to north aligned spray path at a speed of 24 kph. Nozzle pressure was 493 g/cm^2 for the 0.25 and 0.5 g/ha rates of lambda-cyhalothrin and 380 g/cm^2 for the 1.0 and 1.96 g/ha rates of lambda-cyhalothrin and resmethrin, respectively. Droplet size and flow rate calibrations for treatments were conducted on the afternoon of each test shortly before the treatment series. Flow rate for all treatments was 360 ml/min.

Commodore ULV®,[5] a formulation containing 2% lambda-cyhalothrin, was mixed with Orchex 796® at a ratio of 1:6.826 to achieve an application rate of 0.25 g AI/ha with a droplet size of 20.9 microns volume median diameter (VMD). The mixing ratios were 1:2.913 to achieve an application rate of 0.5 g AI/ha (16.4 micron VMD) and 1:0.957 for 1.0 g AI/ha (22.4 micron VMD). Scourge®,[6] a formulation containing 18% resmethrin and 54% piperonyl butoxide, was mixed with Orchex 796® at a ratio of 1:8 to achieve an application rate of 1.96 g resmethrin/ha (28.6 microns VMD).

Caged mosquitoes were exposed to each treatment in an open field in which the grass was ≤ 15 cm high. Stakes suspended the cages 1.5 m above the ground and were placed 25, 50, 100 and 200 m downwind in a line perpendicular to the spray vehicle path. Three rows of cages separated by 25 m were used in each exposure. Control cages of mosquitoes were placed on the stakes 10 min prior to each treatment series and then returned to the polystyrene container for transportation to the laboratory. Cages containing mosquitoes for treatments were placed on the stakes just before each adulticide applica-

[5] Trademark of ICI Americas Inc.

[6] Trademark of Roussel-Bio Corporation.

Table 1. Percent corrected mortality ± SE of caged feral *Anopheles quadrimaculatus* subjected to ground ULV applications of lambda-cyhalothrin and resmethrin.

Treatment	Distance from spray path 25	50	100	200	Mean*
		Lambda-cyhalothrin			
0.25 g/ha	95.0 ± 3.2	96.3 ± 0.8	85.9 ± 12.0	73.2 ± 13.4	87.6 ± 4.8
0.50 g/ha	95.7 ± 2.2	97.2 ± 2.2	95.1 ± 1.4	88.2 ± 1.0	94.0 ± 1.3
1.00 g/ha	99.2 ± 0.4	98.8 ± 1.2	98.7 ± 0.8	99.6 ± 0.4	99.1 ± 0.3
		Resmethrin			
1.96 g/ha	98.8 ± 0.7	98.6 ± 1.0	98.4 ± 1.0	95.7 ± 2.8	97.9 ± 0.8
Mean**	97.2a	97.7a	94.5a	89.2b	

* No significant differences ($P > 0.05$) were indicated among comprehensive means for treatments by ANOVA.

** Comprehensive means for distance followed by the same letter are not significantly different ($P > 0.05$) by Duncan's multiple range tests.

Table 2. Percent corrected knockdown ± SE of caged feral *Anopheles quadrimaculatus* subjected to ground ULV applications of lambda-cyhalothrin and resmethrin.

Treatment	Distance from spray path 25	50	100	200	Mean*
		Lambda-cyhalothrin			
0.25 g/ha	84.3 ± 3.0	82.8 ± 4.6	65.9 ± 10.5	65.6 ± 15.8	74.7B
0.50 g/ha	89.5 ± 4.5	85.3 ± 5.7	84.2 ± 6.0	79.0 ± 1.1	84.5AB
1.00 g/ha	92.7 ± 1.5	91.5 ± 5.6	89.4 ± 5.4	86.0 ± 5.0	89.9A
		Resmethrin			
1.96 g/ha	95.8 ± 0.8	96.0 ± 1.4	95.4 ± 2.2	91.0 ± 1.9	94.5A
Mean**	90.6a	88.9ab	83.8bc	80.4c	

* Comprehensive means for treatment followed by the same upper case letter are not significantly different ($P > 0.05$) by Duncan's multiple range tests.

** Comprehensive means for distance followed by the same lower case letter are not significantly different ($P > 0.05$) by Duncan's multiple range tests.

tion, removed 5 min after the application and similarly returned to the laboratory.

Mosquitoes were anesthetized with CO_2 immediately upon return to the laboratory, transferred to clean half-pint paper cartons with screen lids and provided 10% sugar water solution placed on a cotton pad. Initial knockdown was determined at 1 h, and final mortality was determined at 24 h posttreatment. Data were corrected for control knockdown and mortality, using means for each replication by distance from the spray path, with Abbott's formula (Abbott 1925) and subjected to ANOVA (SAS Institute 1985) using a strip-plot model. Means for whole-plot (treatment) and strip-plot (distance) factors were separated by Duncan's multiple range tests (Duncan 1955). Data were not transformed (arcsine) since the range of percentages was relatively small and near the upper end of the scale.

RESULTS AND DISCUSSION

Average 24-h mortalities for each treatment by distance from the spray path are presented in Table 1. Control mortalities ranged from 1.5 to 10.4%. The treatment by distance interaction was nonsignificant ($P \geq 0.05$); however, results were presented as treatment averages by distance from the spray path for ease of interpretation. Although no significant differences ($P \geq 0.05$) were indicated among the comprehensive means for treatments by ANOVA, Duncan's multiple range tests for differences among comprehensive means for distance indicated significantly ($P < 0.05$) less control at 200 m (89.2% mortality) than at 25, 50 and 100 m (97.2, 97.7 and 94.5% mortality, respectively). All treatments provided impressive activity considering the distance to which they were tested. Ground applied ULV treatments normally are not evaluated beyond a distance of 100 m.

The greatest activity, based on percentage mortality, was provided by the 1.0 g/ha rate of lambda-cyhalothrin. Greater than 98% mortality was achieved by this treatment up to 200 m. Mortality decreased below 90% for the 0.5 and 0.25 g/ha rates of lambda-cyhalothrin at 200 and 100 m, respectively. Resmethrin, applied at 1.96 g/ha, maintained greater than 95% control to a distance of 200 m. Based on the application rates used in this study, lambda-cyhalothrin was slightly superior to resmethrin as a mosquito adulticide. Further, resmethrin was synergized whereas lambda-cyhalothrin was not. Nevertheless, lambda-cyhalothrin applied at the lowest rate used in this test (0.25 g/ha) demonstrated a high degree of activity against *An. quadrimaculatus* adults. This activity was higher than that observed for resmethrin applied at 1.1 g/ha in a previous trial (Weathersbee et al. 1989).

Mean 1-h knockdowns for each treatment by distance from the spray path are presented in Table 2. Control knockdown ranged from 0.88 to 3.24%. Knockdowns were significantly ($P < 0.05$) greater for resmethrin (94.5%) and the 1 g/ha rate of lambda-cyhalothrin (89.9%) than for the 0.25 g/ha rate of lambda-cyhalothrin (74.7%), as indicated by Duncan's multiple range tests for differences among the comprehensive means for treatment. Significantly ($P < 0.05$) less knockdown occurred at 200 m (80.4%) than at 25 m (90.6%) and 50 m (88.9%) with respect to the comprehensive means for distance. The treatment by distance interaction again was nonsignificant ($P > 0.05$).

In general, treatment knockdown values were slightly lower than the respective values for mortality. No recovery was observed in any of the treatments. The difference between 1 h knockdown and 24 h mortality values was more apparent with lambda-cyhalothrin treatments than with the resmethrin treatment. These results indicated that resmethrin demonstrated slightly higher propensity for knockdown than did lambda-cyhalothrin.

Lambda-cyhalothrin appeared to be a highly effective compound for use against *An. quadrimaculatus* adults. Results indicated that the adulticidal activity of this compound applied as a ULV ground spray at 0.5 to 1.0 g/ha was comparable to that achieved by resmethrin applied at 1.96 g/ha. Knockdown activity at these rates was only slightly less than that achieved by resmethrin. Lambda-cyhalothrin appears to have potential as an alternative mosquito adulticide and should be further evaluated for use in operational mosquito control.

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